

DESIGN AND FABRICATION OF A PCB FOR THE CENTRALIZED CONTROL UNIT OF A WIRELESS SENSOR NETWORK

B.Tech in Electronics and Communications Engineering

By

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CERTIFICATE

This is to certify that thesis entitled **“Design and Fabrication of a PCB for the Centralized Control Unit of a Wireless Sensor Network”** has been completed by **Pallabi Mishra**, Roll Number **110EC0173**, National Institute of Technology, Rourkela, India ,during the period July 2013-April 2014 for the Final Year Project 2013-14 under the supervision of **Prof. Debiprasad Priyabrata Acharya**.

(Prof. Debiprasad Priyabrata Acharya)

ABSTRACT

Wireless Sensor Network stands the advantage of having low power, low cost, high accuracy and flexible location. In our Project, we aim to design a Printed Circuit Board which functions as the Centralized Control Unit of a Wireless Sensor Network that is used to detect flood and transmit the information to the Registered Mobile Users in the case of a flood. We integrate Audrino Uno and SIM 900 in our PCB. Audrino UNO is the Processor for analyzing data from the Pressure Sensor Network and predicting the occurrence of a flood. SIM 900 transmits the message of a flood to people in flood-affected region. We use EAGLE Software to draw the Schematic and Board Diagram of the desired PCB after removing desired components and adding desired conditions. We use Circuit CAM to get a Print Out of the PCB.

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PREFACE

Nowadays Embedded system has captured the field of industry as well as domestic or practical life of human beings. Glancing at recent development in the field of electronics and computers, we can just say that they have captured practically every mode of human's life and have given a new way to it. Taking into consideration, the need to save living beings has inspired us to develop a Disaster Management System that remotely controls wide range of appliance, in and around the affected area, with the help of an Embedded System. A Printed Circuit Board is an extremely compact piece of an Electronic Component that can simultaneously embed various features and functions. Integrating a Printed Circuit Board for a Disaster Management system is an excellent way of ensuring a portable and efficient module with desired functions even in remote areas.

Finally we feel very much satisfied in presenting this project, which would be of great use to our society.

ACKNOWLEDGEMENTS

We are extremely grateful to our project guide, Prof. D.P. Acharya for his insightful suggestions on the project work and for guiding us during the project with her encouragement, support and cooperation. We would like to convey our sincerest gratitude and indebtedness to all our faculty members and staffs of Department of Electronics and Communications Engineering, NIT Rourkela, who showed their great efforts and guidance during required times without which it would have been very difficult to carry out our project work. Moreover, an assemblage of this nature could never have been attempted with our reference to the works of others. We acknowledge our indebtedness to all of them. Finally, we would also like to extend our heart- felt thanks to our family for their moral support, love and affection.

INTRODUCTION

The disaster management area is described by: appropriated control; vulnerability, uncertainty, imprecision and inclination; different stakeholders with diverse points and destinations; and restricted assets which consistently fluctuate. A disaster management framework is seen as being made out of self-sufficient, sensitive and proactive executors that can sense, act and interface so as to attain singular and aggregate points. These operators need to have the capacity to make the best utilization of accessible data, be adaptable and coordinated in their choice making, cognisant of the way that there are different executors, and versatile to their nature's turf. This obliges a multi-disciplinary methodology, specifically:

- Filtering and data fusion methods for estimating relevant state variables, such as the position of rescue vehicles and wounded civilians
- Decision-making and machine learning methods for determining actions in response to states, such as when and where to route a particular rescue vehicle
- Multi-agent systems, game theory, and mechanism design methods to manage the interaction between multiple actors and to model collective behaviour
- System architecture studies of different agent organisations and information exchange topologies, for example centralised, hierarchical or decentralised systems

The test is to coordinate these components so as to create decentralized information and data frameworks that can work viably in exceedingly unverifiable and dynamic situations. This is not only an exploration move; it is a key prerequisite for some mechanical and business associations, exemplified by the disaster management requisition area.

FLOOD CONTROL USING ELECTRONICS

Two early types of flood detection and warning systems have been established:

A) Non-WSN and B) WSN

A) Non-WSN Systems:

These frameworks have a primitive strategy of surge identification obliging prepared faculty. It includes generally manual methods and subsequently is unmanageable. Here, the dependability of the whole component relies on the expertise and knowledge of the staff utilized and is hence restricted by their velocity and spryness. Late improvements have prompted mechanized telemetry frameworks. Indeed these are exorbitant as they require occasional establishment of repeaters and transmitters. The vast majority of the telemetric frameworks take after a brought together computational procedure. Likewise sending of an extensive number of telemetric frameworks to blanket the whole locale gets unrealistic because of the substantial costs included. Disregarding having these issues, the non-WSN frameworks are working in numerous nations on the planet.

B) WSN Systems:

WSNs could be characterized as low power, minimal effort, multi-jumping frameworks that are free of outer administration suppliers, can structure an extendable system without viewable pathway scope; however have recovering toward oneself information ways. WSNs could be sent pretty much homogeneously in a land locale utilizing a two-layered methodology having bunches of short separation corresponding hubs together with a few hubs equipped for correspondence over a more extensive reach. WSN hubs correspond just with neighboring hubs to decrease the transmission force and misfortunes, consequently taking out the requirement for unreasonable repeaters and transmitters utilized as a part of conventional telemetry frameworks. Each hub in a WSN can go about as an information obtaining gadget, an information switch and an information aggregator. This construction modeling expands the repetition and therefore the unwavering quality of the whole blaze- surge checking framework. The autonomy from outsider suppliers and the nonattendance of framework prerequisites – as those required in cell based telemetry frameworks

permit a WSN to be conveyed rapidly. They permit on the web, change toward oneself of the forecast mode

Three types of models may be designed:

A) Centralized, B) Distributed or C) Hybrid

A) Centralized Model:

A centralized model is one where calculation happens at the central node just. It needs less number of segments as terminal hubs needn't bother with the electronic parts needed for computational purposes. Nonetheless, the entire framework fizzles if the central node comes up short regardless of the fact that it is just a solitary purpose of disappointment (accepting a completely joined reinforcement of the focal hub is truant). There is additionally a need to stay away from bottlenecks because of transmission of measured information all the while from all the sensing nodes, which can restrict the information accessible to the model to use for alignment and expectation therefore constraining the adaptability of the model.

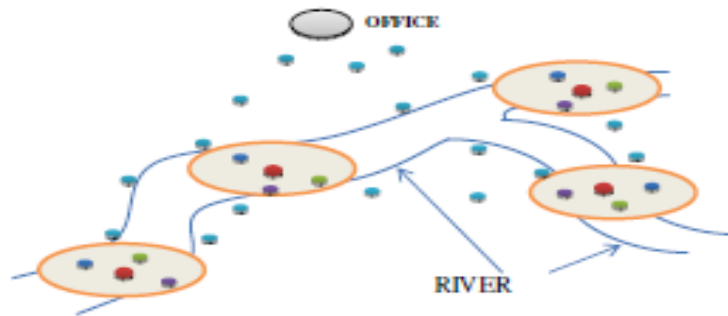
B) Distributed Model:

A distributed model is unified with processings at a few levels rather than stand out registering hub as in the past model. A large portion of the weaknesses of a centralized framework are tended to in this model as diverse terminal sensors act together to give the gathered information to scaffold hubs, distinguish inside disappointments and to adjust to changes in topology. This model likewise expands the dependability of a framework by presenting repetition as the same counts are carried out at diverse hubs and afterward matched. Nonetheless, they experience the ill effects of the trouble and expense of upkeep of various sensors with extra functionalities and likewise in guaranteeing fitting correspondence around these heterogeneous sensors.

C) Hybrid Model:

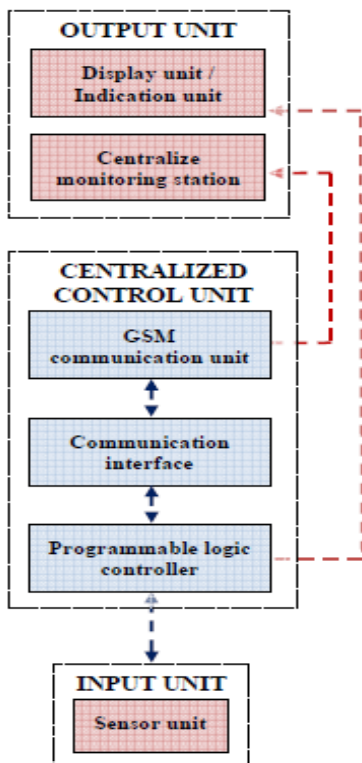
As the name recommends, this model embodies some piece of the centralized model and some piece of the distributed model. The degree to which a piece of each one model (centralized or distributive) is incorporated in it is adaptable and may shift according to framework prerequisites. This model means to halfway consolidate the points of interest of both the above frameworks and at the same time, countervail the inconveniences of either framework by joining both. Despite the fact that the system progression continues as before here as in the past cases, processing is carried out on numerous hubs not at all like the centralized strategy, but calculation in just about all hubs is not done as in the distributed technique. In this manner, it is conceivable to achieve a suitable parity of the expense of organization and the repetition and unwavering quality of the framework as required.

USE OF PRESSURE SENSORS



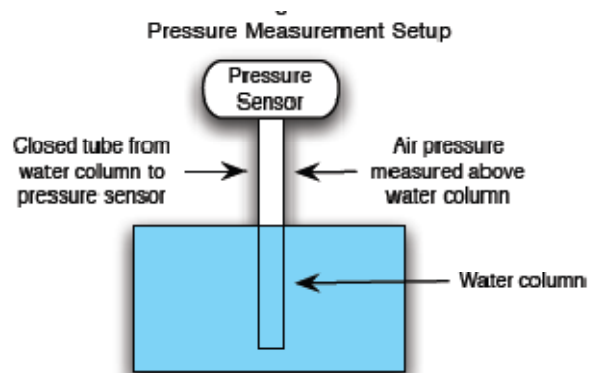
DEPLOYING PRESSURE SENSORS AT MEASURED DISTANCES AND INFORMATION COMMUNICATED TO A COMMON CENTRE

SCHEMATIC DIAGRAM



PRESSURE SENSOR MPXM2010GS

The measurement technique uses the air pressure in a closed tube above a column of water to determine the water level. The following diagram shows the basic components of the measuring system. As the water level in the column changes, the air pressure in the closed tube above the column will change proportionally. By measuring the air pressure, the water level can be determined.



Water measurement column located under dock.



Water measurement column with tube leading to pressure sensor.



Pressure sensor with tube coming from water measurement column.



PRINTED CIRCUIT BOARD

A printed circuit board (PCB) mechanically supports and electrically connects electronic segments utilizing conductive tracks, cushions and different characteristics carved from copper sheets overlaid onto a non-conductive substrate. PCBs might be single sided (one copper layer), twofold sided (two copper layers) or multi-layer. Conductors on distinctive layers are joined with plated-through gaps called vias. Propelled PCBs may hold segments - capacitors, resistors or dynamic gadgets - implanted in the substrate.

Printed circuit sheets are utilized as a part of everything except the most straightforward electronic items. Alternatives to PCBs incorporate wire wrap and point-to-point development. PCBs require the extra plan exertion to lay out the circuit yet assembling and get together could be computerized. Assembling circuits with PCBs is less expensive and speedier than with other wiring strategies as part are mounted and set up with one single part. Moreover, driver wiring lapses are wiped out.

At the point when the board has just copper associations and no inserted segments it is all the more accurately called a printed wiring board (PWB) or scratched wiring board. Despite the fact that more exact, the term printed wiring board has fallen into neglect. A PCB populated with electronic segments is known as a printed circuit get together (PCA), printed circuit board gathering or PCB gathering (PCBA). The IPC favored term for gathered prepares to leave is circuit card gathering (CCA), for amassed backplanes it is backplane gatherings. The term PCB is utilized casually both for exposed and collected sheets.

The world business sector for uncovered PCBs arrived at almost \$60 billion in 2012.

DESIGN

Printed circuit board artwork generation was at first a completely manual procedure done on clear mylar sheets at a scale of normally 2 or 4 times the coveted size. The schematic chart was initially changed over into a design of

segments pin cushions, then follow were steered to give the obliged interconnections. Preprinted non-imitating mylar networks supported in format, and rub-on dry exchanges of basic courses of action of circuit components (cushions, contact fingers, incorporated circuit profiles, et cetera) helped institutionalize the design. Follow between gadgets were made with sticky toward oneself tape. The completed format "artwork" was then photographically recreated on the oppose layers of the spotless covered copper-clad sheets.

Current practice is less work-serious since machines can consequently perform a number of the format steps. The general movement for a business printed circuit board configuration might include:

1. Schematic capture through an electronic configuration automation device.
2. Card measurements and format are chosen focused around obliged hardware and instance of the PCB. Focus the altered segments and heat sinks if needed.
3. 1 to 12 layers or all the more relying upon design complexity. Ground plane and force plane are chosen. Signal planes where indicators are directed are in top layer and also inside layers.
4. Line impedance determination utilizing dielectric layer thickness, steering copper thickness and follow-width. Trace separation likewise considered if there should arise an occurrence of differential indicators. Microstrip, stripline or double stripline might be utilized to course indicates.
5. Placement of the segments. Thermal considerations and geometry are considered. Vias and lands are checked.
6. Routing the signal traces. For ideal EMI performance high frequency signals are steered in interior layers between power or ground planes as power planes carry on as ground for AC.
7. Gerber file generation for assembling.

In the outline of the PCB craftsmanship, a force plane is the partner to the ground plane and carries on as an AC sign ground, while giving DC voltage to controlling circuits mounted on the PCB. In electronic configuration computerization (EDA) outline devices, force planes (and ground planes) are normally drawn naturally as a negative layer, with clearances or associations with the plane made consequently.

MANUFACTURING

PCB assembling comprises of numerous steps.

PCB Cam

Producers never utilize the Gerber or Excellon files straightforwardly on their supplies, however dependably read them into their CAM framework. PCB's can't be produced professionally without a CAM framework. The PCB CAM framework performs the accompanying functions:

1. Information of the Gerber information
2. Confirm the information; alternatively DFM
3. Make up for deviations in the assembling courses of action (e.g. scaling to make up for twists throughout overlay)
4. Panelize
5. Yield of the computerized instruments (layer pictures, drill files, AOI information, electrical test files,.)

Panelization

Panelization is a methodology used to handle PCBs which might overall be so little it is not possible procedure. Various indistinguishable circuits are printed onto a bigger board (the board) which can then be taken care of in the typical way. The board is broken separated into unique PCBs when all other preparing is finished.

Dividing the distinct PCBs is much of the time supported by boring or steering punctures along the limits of the distinctive circuits, much like a sheet of postage stamps. An alternate technique, which consumes less room, is to cut V-formed scores over the full measurement of the board. The distinct PCBs can then be broken separated along this line of weakness.

The procedure of evacuating distinctive PCBs from a bigger board is called Depaneling. While penetrated/steered punctures and furrows were normal for various years, today this is regularly done by lasers, which cut the board with no contact. This diminishes the burdens on the delicate circuits brought on by torque. This system is regularly totally robotized with full loads up entering the laser depaneling machine by means of transport, being cut into distinctive pieces by laser, and leaving the framework through transport, and here and there stacked, on the other side.

Copper patterning

The pattern in the producer's PCB CAM framework is generally yield on a photomask (photo-tool, film) by a photoplotter and repeated by means of silk screen printing or by uncovering on a photograph-delicate photoresist covering. Immediate imaging methods are at times utilized for high-resolution prerequisites.

Lamination

Multi-layer printed circuit boards have trace layers inside the board. One approach to make a 4-layer PCB is to utilize a two-sided copper-clad cover, scratch the hardware on both sides, then overlay to the top and bottom prepreg and copper foil. Overlay is carried out by setting the stack of materials in a press and applying weight and high temperature for a time of time. This outcomes in an indistinguishable one piece item. It is then bored, plated, and scratched again to get follow on top and bottom layers. At last the PCB is secured with patch cover, checking legend, and a surface completion may be connected. Multi-layer PCBs take into consideration much higher segment thickness.

WHAT OUR PCB CONTAINS

1. ARDUINO UNO

It functions as the processor for acquiring data from the Pressure Sensors, processing them for predicting floods, storing the desired data and transmitting the Flood Alarms.

Arduino is a single-board microcontroller, proposed to make the requisition of intuitive questions or situations more accessible. The hardware comprises of an open-source hardware board composed around a 8-bit Atmel AVR microcontroller, or a 32-bit Atmel ARM. Current models offer a USB interface, 6 simple information pins, and 14 computerized I/O pins which permits the client to join different expansion sheets.

Presented in 2005, it was intended to give understudies a cheap and simple approach to program intuitive items. It accompanies a straightforward coordinated the earth (IDE) that runs on customary Pcs and permits to compose programs for Arduino utilizing C or C++.

An Arduino board comprises of an Atmel 8-bit AVR microcontroller with correlative segments to encourage programming and joining into different circuits. A vital part of the Arduino is the standard way that connectors are uncovered, permitting the CPU board to be associated with a mixture of compatible extra-modules known as shields. A few shields speak with the Arduino board straightforwardly over different pins, yet numerous shields are exclusively addressable by means of an I²c serial transport, permitting numerous shields to be stacked and utilized within parallel. Official Arduinos have utilized the megaavr arrangement of chips, particularly the Atmega8, Atmega168, Atmega328, Atmega1280, and Atmega2560. A handful of different processors have been utilized by Arduino compatibles. Most sheets incorporate a 5 volt straight controller and a 16 Mhz precious stone oscillator (or ceramic resonator in a few variants), in spite of the fact that a few outlines, for example, the Lilypad run at 8 Mhz and forgo the locally available voltage controller because of particular structure-element limitations. An Arduino's microcontroller is likewise prearranged with a boot loader that rearranges transferring of projects to the on-

chip streak memory, contrasted and different gadgets that normally require an outer software engineer. This makes utilizing an Arduino more direct by permitting the utilization of a normal machine as the software engineer.

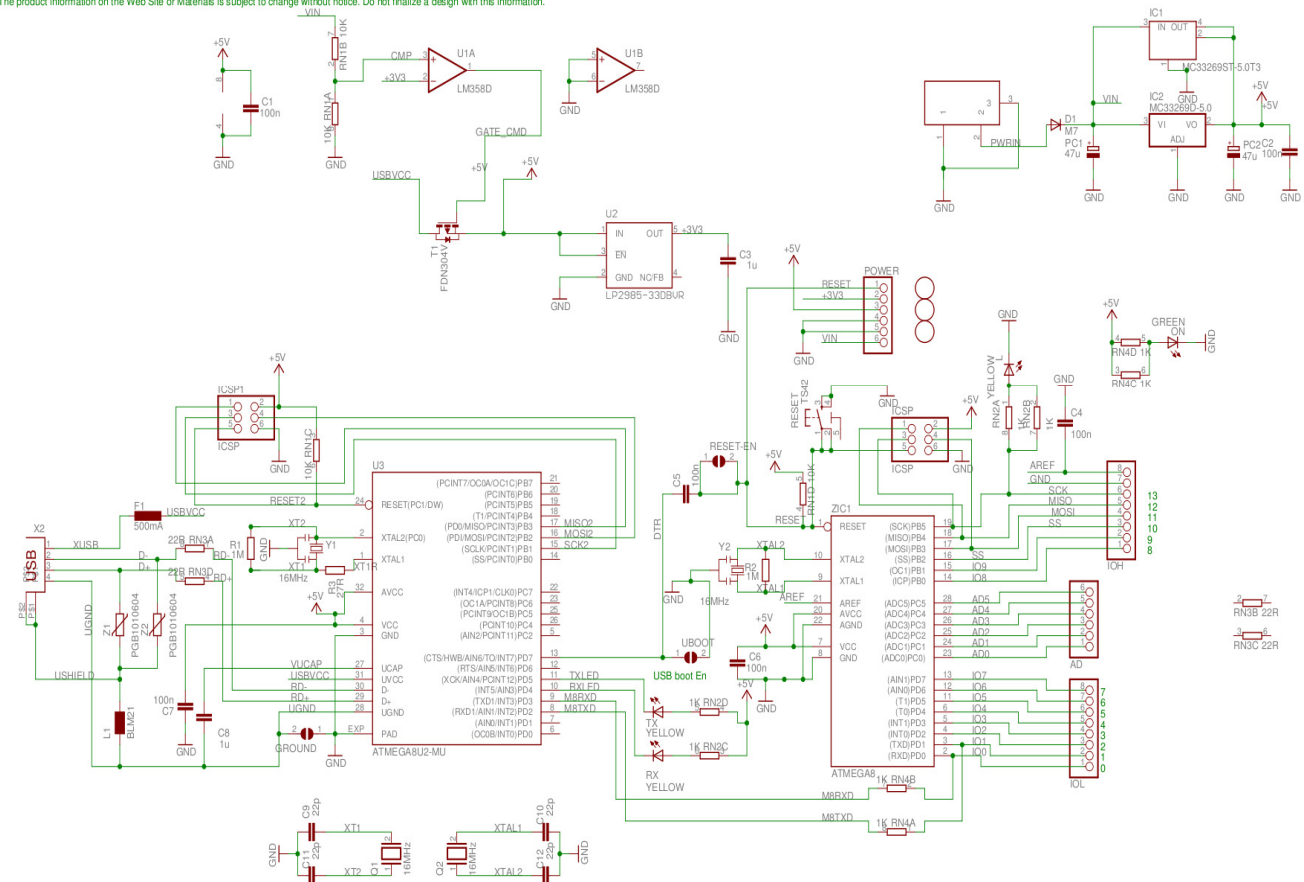
The Arduino board uncovered the majority of the microcontroller's I/O pins for utilization by different circuits. The Diecimila, Duemilanove, and current Uno give 14 computerized I/O sticks, six of which can generate beat-width balanced signs, and six simple inputs. These pins are on the highest point of the board, by means of female 0.10-inch (2.5 mm) headers. A few module-requisition shields are likewise financially accessible.

SCHEMATIC DIAGRAM

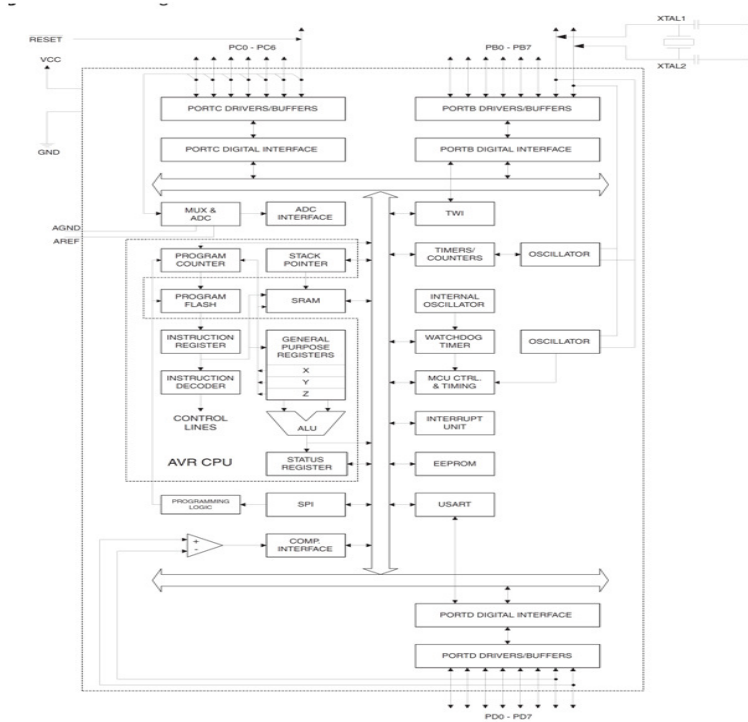
Arduino™ UNO Reference Design

Reference Designs ARE PROVIDED "AS IS" AND "WITH ALL FAULTS". Arduino DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING PRODUCTS, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

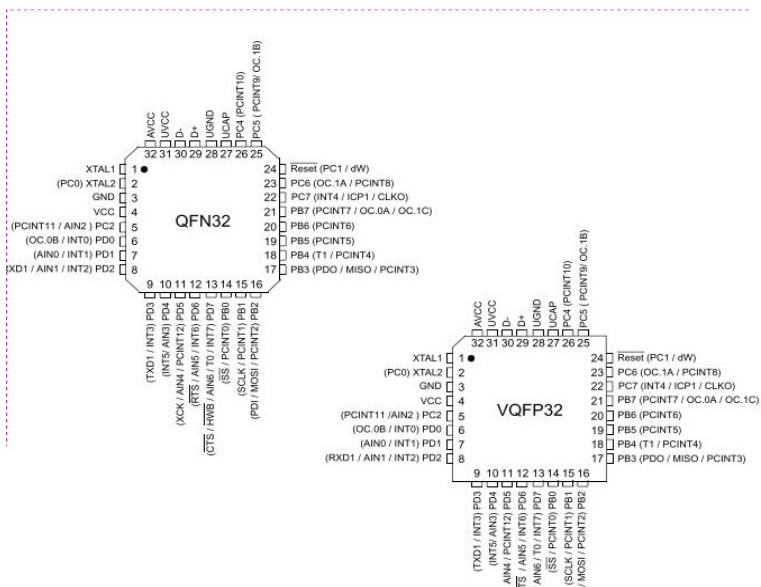
Arduino may make changes to specifications and product descriptions at any time, without notice. The Customer must not rely on the absence or characteristics of any features or instructions marked "reserved" or "undefined". Arduino reserves these for future definition and shall have no responsibility whatsoever for conflicts or incompatibilities arising from future changes to them. The product information on the Web Site or Materials is subject to change without notice. Do not finalize a design with this information.

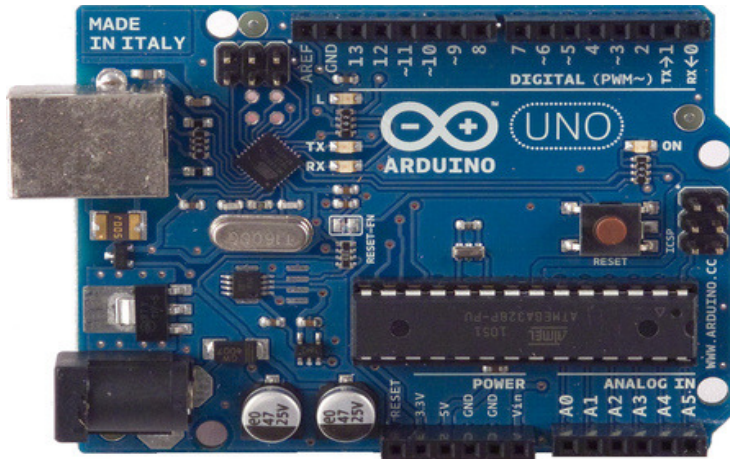


ATMEGA8



ATMEGA8U2-MU





2. SIM 900

This is the IC which supports the SIM and helps in transmitting and receiving all the Information to the Registered Mobile Phones in the flood-prone area.

SIM5215 The SIM5215 series is a Multi-Band WCDMA/GSM/GPRS/EDGE module solution which supports WCDMA 384kbps for data transfer. With abundant application capability like embedded LUA script, TCP/UDP/FTP/HTTP/HTTPS/SMTP/POP3 and MMS, the module provides much flexibility and ease of integration for customer's application.

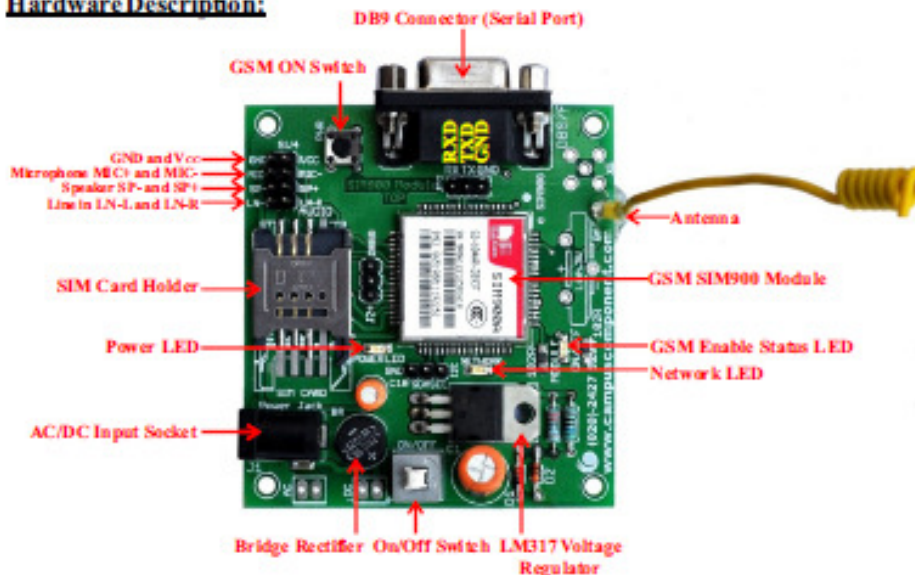
Its unique camera/video call feature shall add value to security solutions. It is ideal for a wide range of products including AMR, Gateway, Telematics, Tracking solution, Security solution and much more.

FEATURES

- Quad Band GSM/GPRS : 850 / 900 / 1800 / 1900 MHz
- Built in RS232 to TTL or viceversa Logic Converter (MAX232)
- Configurable Baud Rate
- SMA (SubMiniature version A) connector with GSM L Type Antenna
- Built in SIM (Subscriber Identity Module) Card holder
- Built in Network Status LED
- Inbuilt Powerful TCP / IP (Transfer Control Protocol / Internet Protocol) stack for internet data transfer through GPRS (General Packet Radio Service)

- Audio Interface Connectors (Audio in and Audio out)
- Most Status and Controlling pins are available
- Normal Operation Temperature : -20 °C to +55 °C
- Input Voltage : 5V to 12V DC
- LDB9 connector (Serial Port) provided for easy interfacing

Hardware Description:

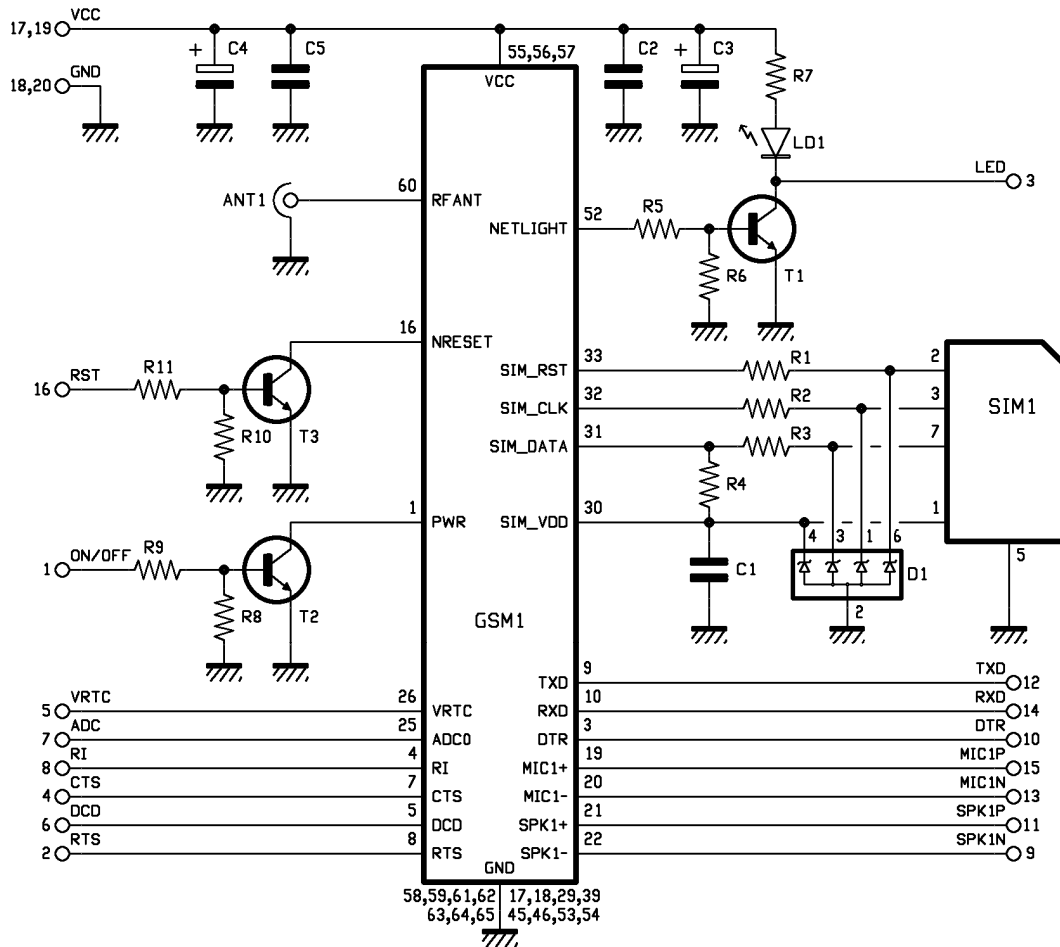


SIM (Subscriber Identity Module) Card Slot:

This onboard SIM card slot provide User functionality of insert a SIM (GSM only) card of any service provider. While inserting in and removing out SIM card from SIM card slot, User needs to take precaution that power supply should be OFF so that after making Power supply ON it will be easy to reinitialize with SIM for this module.



SCHEMATIC DIAGRAM



REMOVING THE REDUNTANT COMPONENTS

Now, we move on to remove the reduntant designs in the PCB. There are certain components which are just for testing the functionality of various parts or checking the consistency which we are removing here for the puprpose of making a Compact PCB.

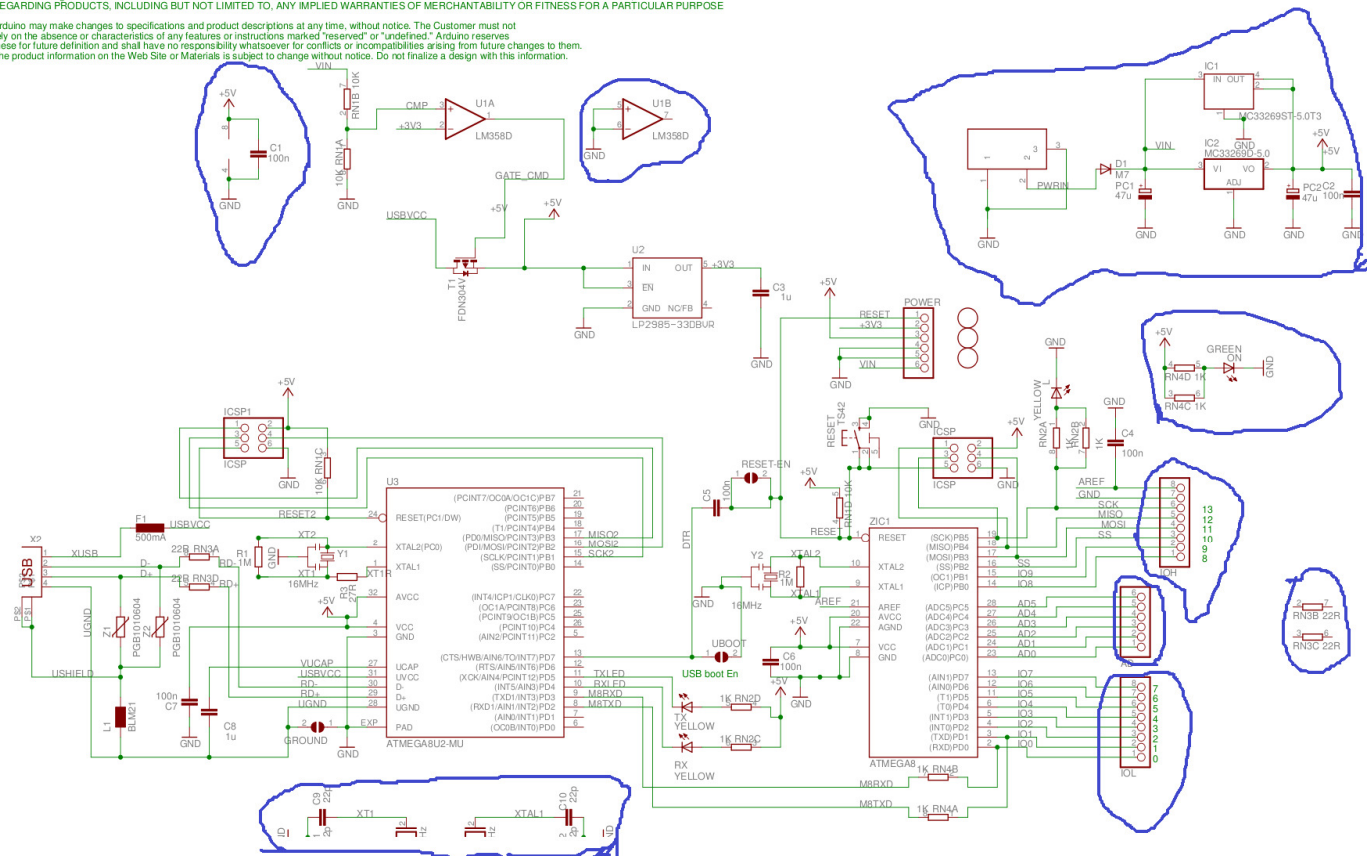
At this stage, we remove the individual redundant components from each Component individually. In the net stage, we are going to merge both of them.

ARDUINO UNO

Arduino™ UNO Reference Design

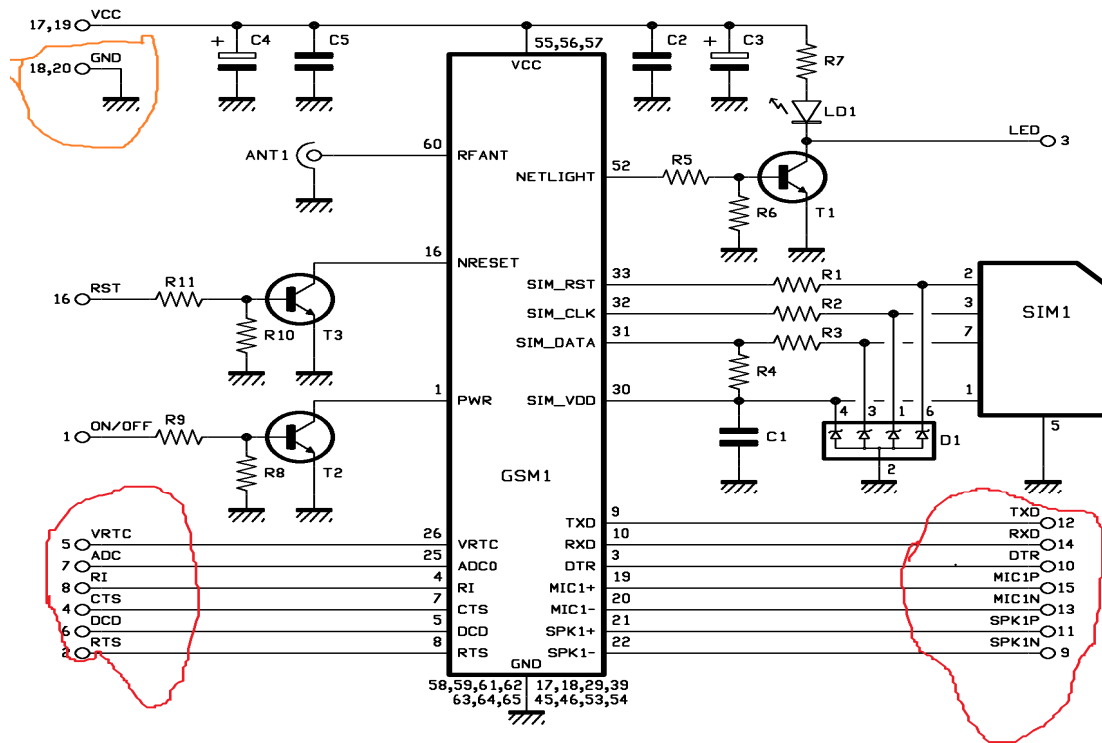
Reference Designs ARE PROVIDED "AS IS" AND "WITH ALL FAULTS". Arduino DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED. REGARDING PRODUCTS, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

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The above diagram shows components or connections which are not used in Arduino UNO Board.

SIM 900



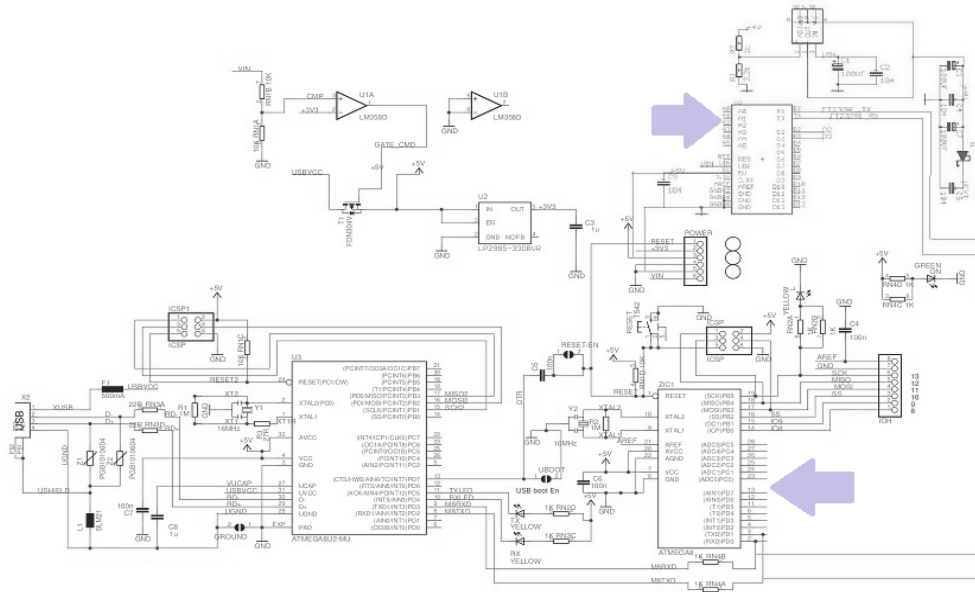
This diagram shows various connections and components that are not required in the main design.

ESTABLISHING THE NECESSARY CONNECTIONS

After all the redundant components and connections are removed, all we need to do is to establish the necessary connections. There are four important connections that we need to make:

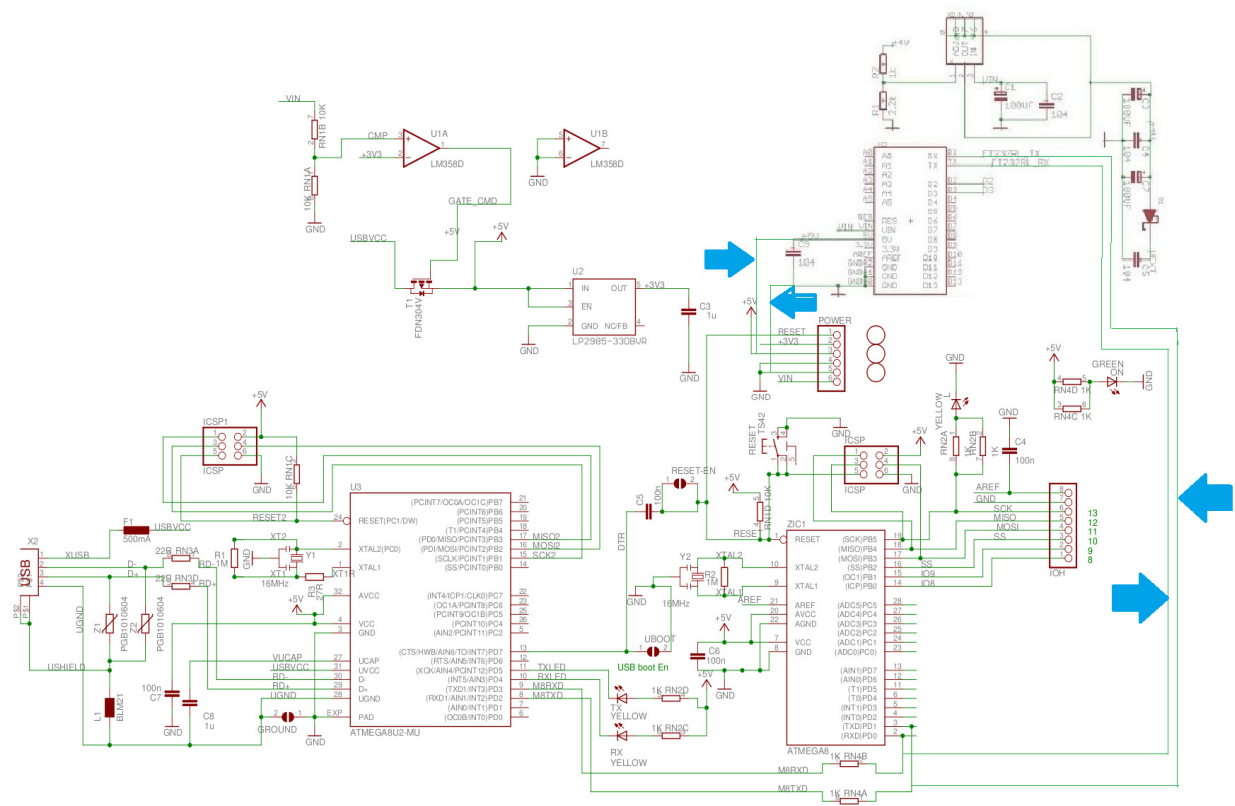
1. Connecting Transmitter Pin of Arduino UNO to Receiver Pin of SIM 900.
2. Connecting Receiver Pin of Arduino UNO to Transmitter Pin of SIM 900.
3. Connecting VCC of Arduino UNO to VCC SIM 900.
4. Connecting Ground of Arduino UNO to VCC SIM 900.

We represent this in the Diagram connecting the two Components as under:



The Diagram shows the two important ICs being integrated.

The four important connections are as shown in the Figure below:



SOFTWARES USED

1. EAGLE Software
2. Circuit CAM Software

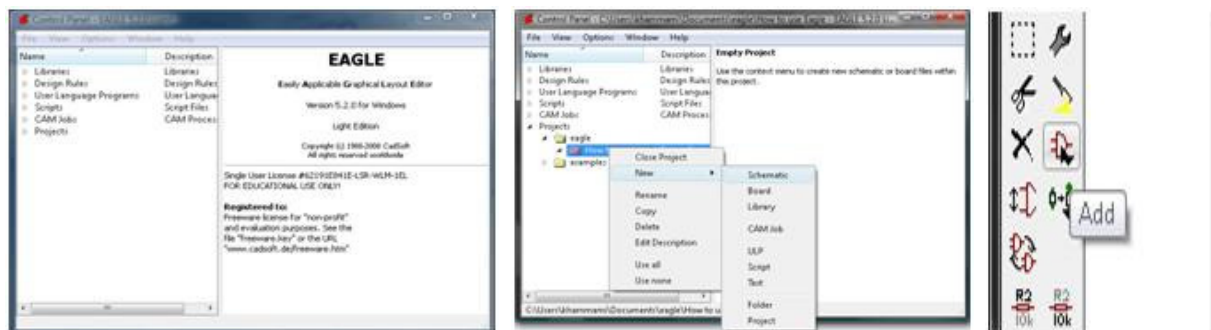
EAGLE IMPLEMENTATION

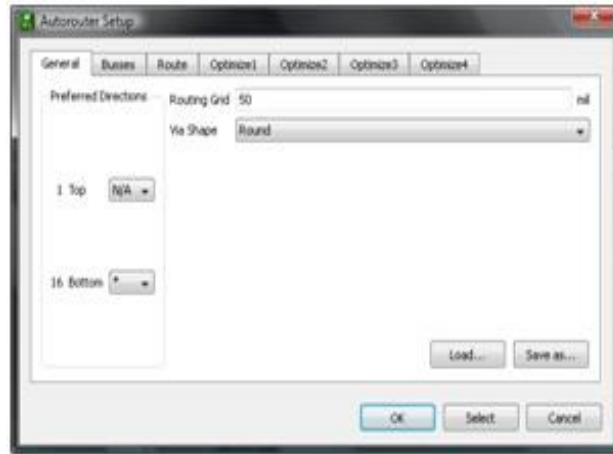
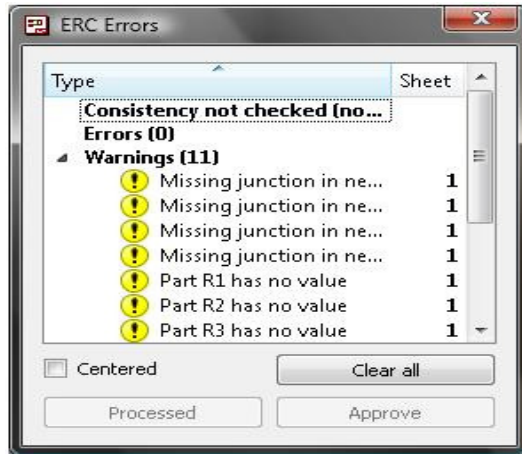
A BIT ABOUT EAGLE

EAGLE (Easily Applicable Graphical Layout Editor, German: Einfach Anzuwendender Grafischer Layout-Editor) by CadSoft Computer is a flexible, expandable and scriptable EDA application with schematic capture editor, PCB layout editor, auto-router and CAM and BOM tools developed by CadSoft Computer GmbH, Germany since 1988.

WORKING AROUND WITH EAGLE

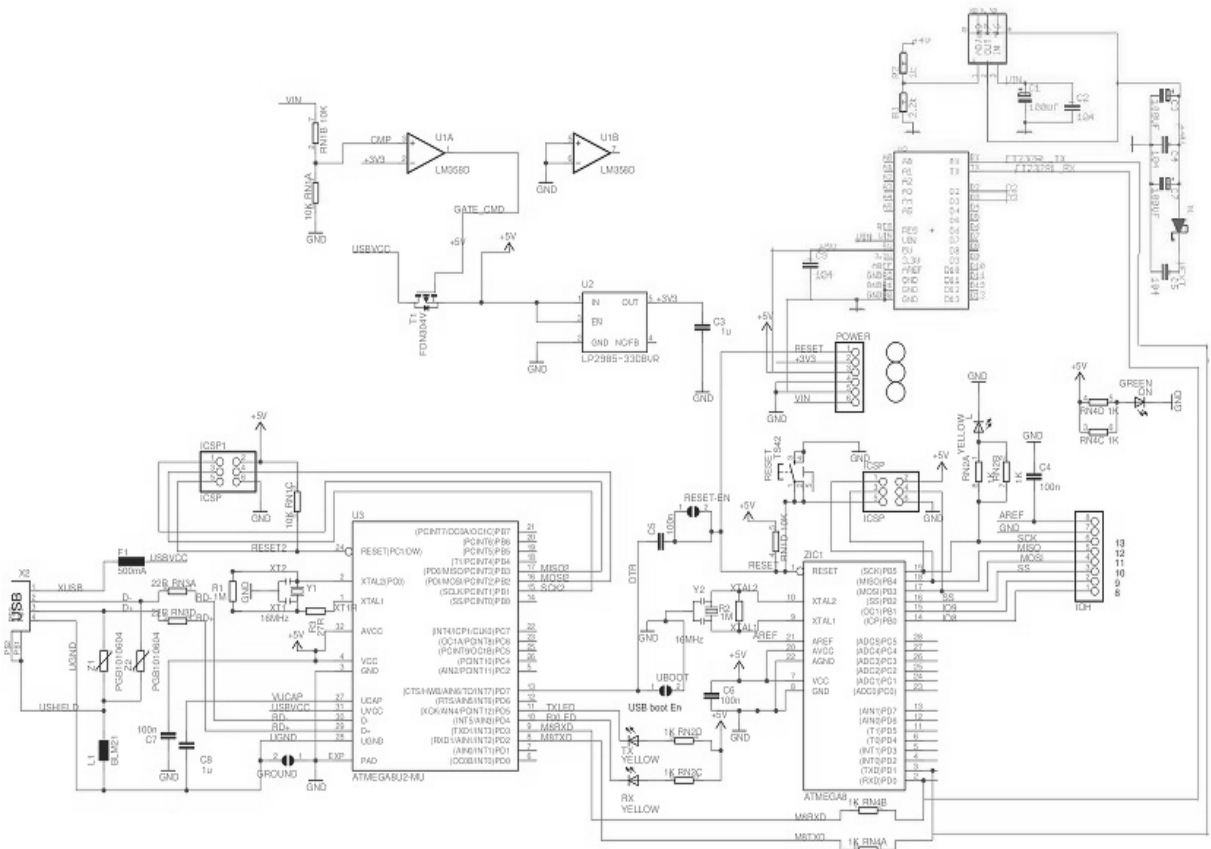
We show here few Snapshots we get while starting with EAGLE and initializing various Components and Libraries.



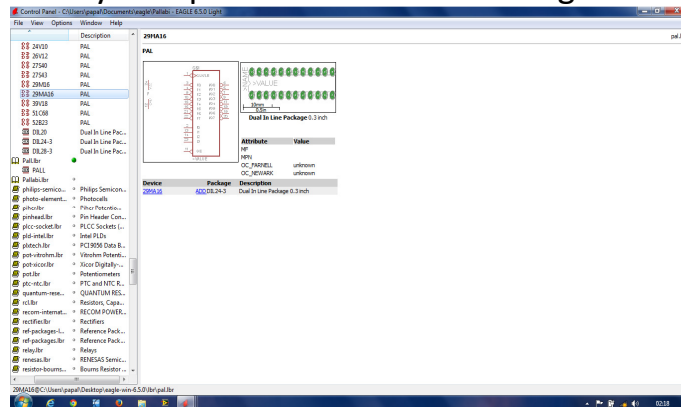


MOVING ON WITH OUR PROJECT

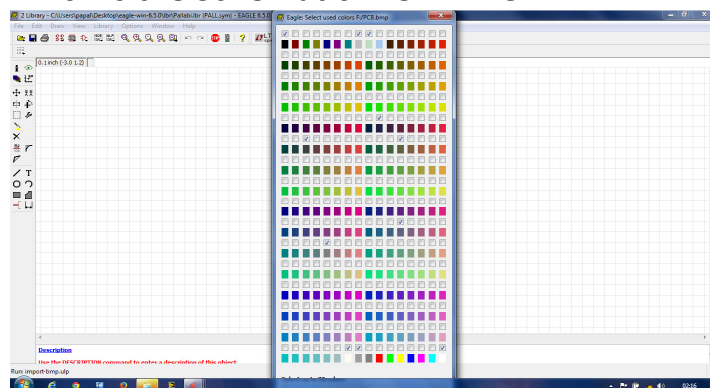
Shown below is the Final PCB Schematic Diagram that we need to implement in Hardware:



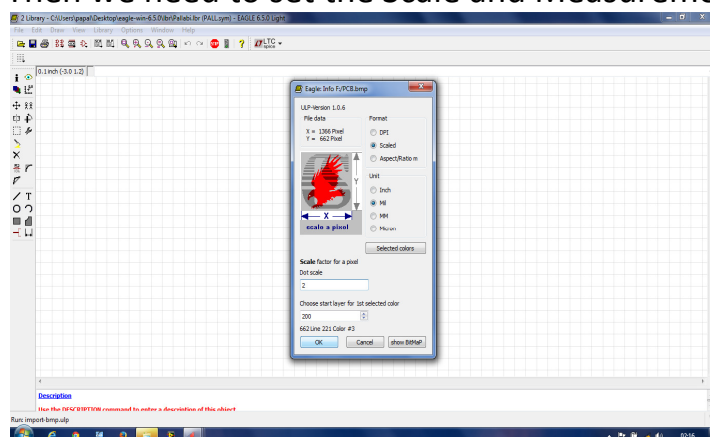
EAGLE has a fascinating Facility that enables us to convert our Bitmap Image directly to a Library in Schematic. Shown below is a sample of one of the various Library Components that have been generated directly from the .bmp File:



We need to select 32 out of 256 Colours for converting .bmp File into the >sch which is the Schematic File in EAGLE.



Then we need to set the Scale and Measurement Unit for the Schematic.



A Script is generated automatically which can then get converted to .sch File.

Finally our CAM File is ready for further processing in the Circuit CAM Software.

CIRCUIT CAM IMPLEMENTATION

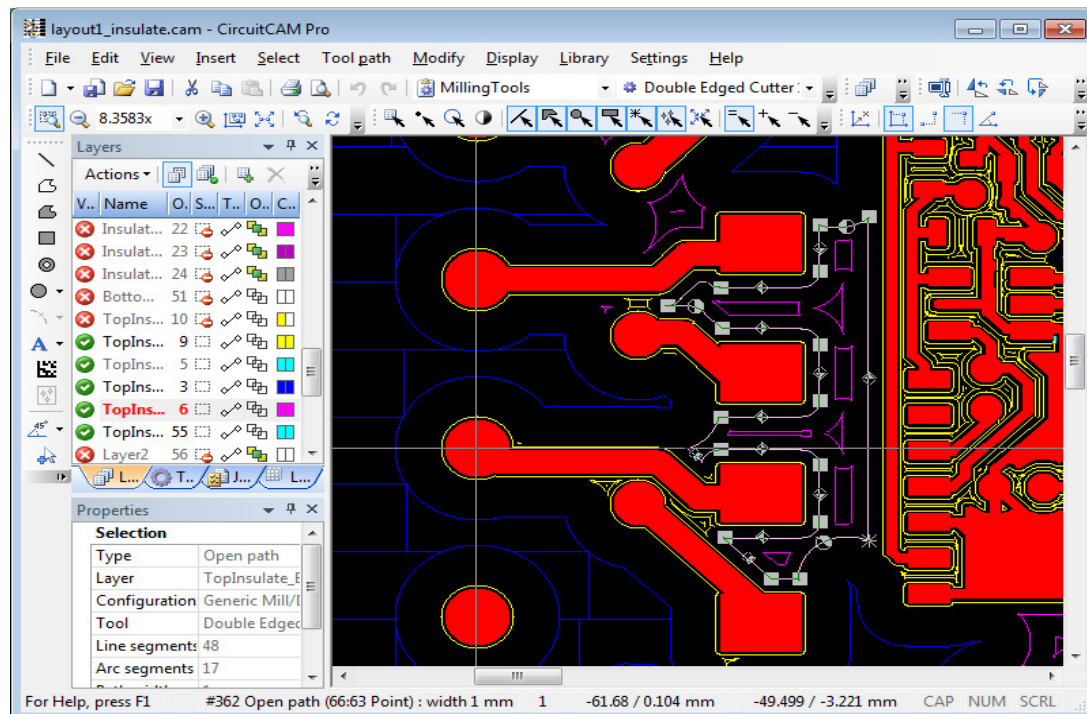
A BIT ABOUT CIRCUIT CAM

CircuitCAM is a Computer Aided Manufacturing (CAM) system for Printed Circuit Boards (PCB) and other related technologies from LKSoft. It is supporting technologies for both prototyping and line production. The supported manufacturing processes we are using here are:-

- Data preparation for photo-plotter.
- Conventional milling and drilling (contour routing) including optimization of tool-paths.

WORKING AROUND WITH CIRCUIT CAM

Shown below is a snapshot taking while implementating the Circuit with Circuit CAM.



CONCLUSION

After proper implementation in EAGLE Software as well as Circuit CAM Software, we have a .cam File which can be printed to get our Final Printed Circuit Board which embeds all our desired characteristics as well as is portable and efficient to serve as the Centralized Control Unit of a Wireless Sensor Network and can be used in remote areas for prediction of flood as well as passing on Alert Messages about the occurrence of a flood to the Registered Mobile Numbers.

Further testing on the Printed Circuit Board using Code and the Pressure Sensor Network may show us areas where we need to improve and customize so as to make our PCB better and efficient.

SOURCES AND CITATIONS

1. <http://www.airborn.com.au/layout/pcbtut.html>
2. <http://www.smps.us/layout.html>
3. <http://www.wikipedia.com>
4. <http://scholar.google.com>